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BEFORE THE

Federal Communications Commission

WASHINGTON, D.C. 20554

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In The Matter of	)	
	)	
Amendment of Parts 22, 90 and 94	)	
of the Commission's Rules to	)	**WT Docket No. 95-70**
Permit Routine Use of	)	
Signal Boosters	)	

To: The Commission

COMMENTS
OF
TX RX SYSTEMS, INC.

TX RX SYSTEMS, INC.

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Dated: August 14, 1995

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SUMMARY

TX RX Systems, Inc. ("TX RX") supports the majority of the Commission's proposals concerning the use of signal boosters. TX RX believes the Commission has correctly recognized the importance of signal boosters to American business and industry. Since signal boosters are used in several different services to overcome a variety of obstacles, TX RX endorses the Commission's flexible approach to their regulation. TX RX requests the Commission to extend this flexible approach to a common application of signal boosters -- one-way VHF paging.

TX RX believes that the Commission's proposal to impose a 500 milliwatt limit on signal booster output would unnecessarily constrain current and future applications of signal boosters. Similarly, TX RX urges the Commission to reconsider its proposal to determine output power of Class B signal boosters by dividing the total available signal booster power by the number of authorized frequencies the signal booster is retransmitting. This proposal would needlessly restrict the application and operation of Class B signal boosters.

TX RX routinely provides output level control circuitry as an integral part of its Class B signal boosters. Output level control circuitry adequately ensures that a signal booster will not function outside of the Commission's spurious emission limits. Thus, TX RX submits that the Commission should apply its spurious emission limits for allowable output levels for both Class A and Class B signal boosters. Entities would be responsible for compliance with the spurious emission limits and would need to employ output level control circuitry in Class B signal boosters wherever appropriate.

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COMMENTS
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TX RX SYSTEMS, INC.

TX RX, by its attorneys, pursuant to Section 1.415 of the Rules and Regulations of the Federal Communications Commission ("Commission"), respectfully submits the following Comments in response to the Notice of Proposed Rule Making ("Notice") released in the above-styled matter by the Commission on June 22, 1995.[1] The Commission has proposed in this proceeding to amend its Rules and Regulations to permit licensees to routinely use signal boosters in Part 22 common carrier paging operations; Part 90 land mobile radio and paging operations; and Part 94 multiple address system ("MAS") operations.

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[1] 60 Fed. Reg. 33782 (June 29, 1995). The dates for filing Comments and Reply Comments were extended to August 14, 1995 and September 1, 1995, respectively, by Order of the Commission. 60 Fed. Reg. 36772 (July 18, 1995).

I. PRELIMINARY STATEMENT

1. TX RX designs and manufactures radio signal boosters, amplifiers, and related equipment, including filters, multicouplers and combiners. Customers of TX RX use radio signal boosters to fill in dead spots in their coverage area for private land mobile dispatch systems, private and common carrier paging systems, and in the Private Operational-Fixed Microwave Service. Dead spots are often found in areas such as tunnels, underground parking facilities, on cargo ships, and in aircraft hangars. A signal booster does not extend the geographic coverage area of the radio system. Rather, it enables the signal to reach parts of the coverage area that are otherwise blocked by terrain or structures. Particular safety applications include use of signal boosters for communication inside nuclear power plants, in public transportation systems such as subways, and in manufacturing plants such as automobile assembly plants. Radio coverage as can be provided by signal boosters is often required by local fire departments if firefighters are expected to enter large multi-story buildings.

2. Dead spots in coverage are persistent problems for the point-to-multipoint or omnidirectional signals transmitted by operational-fixed and mobile radio systems. An even bigger problem is portable talk-out from the inside of a building or other obstruction to the outside. Advancements in signal booster technology, and in overall communications capabilities, have reached a point where system engineers and users expect complete radio signal coverage in their authorized areas.

II. COMMENTS

3. TX RX applauds the Commission's proposals to ease the regulatory burdens which the rules currently impose on licensees employing signal boosters in order to permit them to better serve their authorized service areas; in fact, TX RX filed the Petition for Rule Making which led to the initiation of this rule making proceeding.[2] The Commission's proposed rule changes are entirely fitting in light of the fact that a signal booster does not extend the originally transmitted signal beyond the previously established service area. The Commission correctly recognized that signal boosters simply provide signal

[2] Petition for Rule Making, RM-8200, filed on February 25, 1993.

coverage in areas where the normal, non-boosted signal is obstructed. TX RX supports the Commission's plan to expand the use of signal boosters to: (1) Part 22 common carrier paging operations in the band 931-932 MHz; (2) Part 90 land mobile radio operations in all frequency bands above 150 MHz; (3) Part 90 paging operations in the band 929-930 MHz; and (4) Part 94 MAS operations in the band 928-960 MHz. Notice at ¶¶ 5, 6

4. TX RX agrees with the Commission's proposal to permit licensees to choose their antennas rather than require all licensees to use a certain type of antenna. Notice at ¶ 7. Furthermore, TX RX endorses the Commission's proposal that all signal boosters must fulfill the out-of-band emission requirements currently specified in the rules. Notice at ¶ 8.

5. TX RX believes the Commission was correct to reject the suggestion that a licensee obtain separate authorization for the operation of a signal booster. Notice at ¶ 11. Instead, the Commission has properly proposed that licensees in Parts 22, 90 and 94 may operate signal boosters -- on frequencies and in geographic areas in which they are already authorized to operate -- without separate authorization from the Commission. Notice at ¶ 12.

Particularly, since it will avoid unnecessary regulatory burdens, TX RX fully supports the Commission's proposal to permit licensees to employ signal boosters in order to penetrate structures or other obstacles within the area customarily served by the licensee's system without requiring the licensee to obtain specific authorization from the Commission to operate such signal boosters, provided that the signal boosters have been previously type-accepted. Notice at ¶ 12.

A. Part 22 VHF Paging Operations Should Be Included

6. There are three specific proposals which TX RX urges the Commission to further consider. First, TX RX urges the Commission to permit use of signal boosters for Part 22 VHF paging operations. See, 47 C.F.R. § 22.531. While the Commission proposed to permit use of signal boosters in Part 22 common carrier paging operations in the band 931-932 MHz, signal boosters also play a critical role in Part 22 paging operations in the VHF region. This VHF paging normally involves a one-way communication; the signal is picked up outside the building by a signal booster and simply reradiated by signal boosters within the building so that it can be distributed to individual areas and rooms. Signal boosters are commonly used for VHF paging in hospitals, nuclear facilities, and similar structures where

the walls cannot be readily penetrated and signals must be distributed. Since the signal is brought from the outside and distributed within an enclosed structure, signal boosters used for VHF paging operations pose very little threat of interference to other systems.

B. The Proposed 500 Milliwatt Limit is Unnecessary

7. The Commission's plan to limit the total output power of a signal booster to 500 milliwatts is unnecessary and detrimental to the users and manufacturers of signal boosters. Notice at ¶ 8. Signal boosters do not increase the geographic range of a transmitted signal and do not transmit the radio signal over a different frequency. Notice at ¶ 8. Thus, the inherent qualities of signal boosters serve to limit the impact of signal boosters upon co-channel systems in nearby areas.

8. As the Commission knows, a party meeting the spurious output specifications does not experience freedom from interference in all instances. When necessary, output filtering can reduce radiated noise on nearby receiver frequencies. In addition, transmitter intermodulation may require a ferrite isolator at the transmitter output.

9. Transmitters can be combined with a common antenna and operated simultaneously without harmful interference through the use of filters and ferrite isolators. These devices are called multicouplers, and they have been in use for decades. These same techniques for interference reduction are used to combine one-way signal boosters, primarily the Class A types. Such techniques can result in considerable signal loss, which is a primary reason that the Commission should not restrict the output power level for Class A signal boosters.

10. TX RX stresses that there should be no limits on the output power of Class A or Class B signal boosters. The rules already stipulate that signal boosters must be FCC type-accepted to the same standards as base station transmitters. Thus, as long as the output of Class A or Class B signal boosters remains in compliance with the Commission's spurious emission and occupied bandwidth standards, licensees will ensure that the system coverage area is within authorized limits and signal boosters do not cause interference with other users.

C. Output Power of Class B Signal Boosters

11. TX RX requests the Commission to carefully review its proposal to determine output power of broadband ("Class B") signal boosters by dividing the total available signal booster power by the number of authorized frequencies (channels) that the signal booster is retransmitting. Notice at ¶ 8. The level of the RF output signal which is conveyed on any one frequency is determined by the number and level of all signals presented to the RF amplifier. In cases where there is a potential for large signal variation, or where unwanted signals may be received from off-the-air sources, signal boosters typically employ output level control circuitry. Output level control circuitry ensures that the signal booster will not function outside of the Commission's spurious emission specification. Thus, signal boosters are self-regulating; when a licensee seeks to amplify additional signals, the output power for each signal diminishes if the total power exceeds the preset limit.

12. It should be noted that there is not a simple, catch-all formula that can be applied to the single carrier power output of the Class B amplifier that will determine the permissible power per carrier for multi-carrier amplification. TX RX questions the Commission's reference to "available booster power." Notice at ¶ 8. It is unclear

how it is to be determined. If it is the 1 dB output compression point for a single carrier output, this is acceptable for a Class A signal booster since it will only amplify a single carrier. TX RX requests that the Commission clarify this proposal.

13. Power transistors are rated for output power at the 1 dB output compression point. This means that a transistor capable of 10 dB gain has its power output rated for the condition which requires an input drive level 1 dB greater than would be expected for a 10 dB gain transistor; that is, 9 dB below the output level rather than 10 dB. In other words, the gain is compressed 1 dB at this input drive level.

14. In a real life bi-directional booster design, filters are required at the input and output of the amplifier chain. The loss of the filters following the amplifier will reduce the 1 dB output compression point on a dB-for-dB basis. If a basic amplifier has a 6 watt, or +37.8 dBm, 1 dB output compression point power rating, and it is followed by a filter with 3 dB loss, then the 1 dB output compression point for the booster is +34.8 dBm, or 3 watts.

15. Utilizing the Commission's method for determining the multi-carrier output power level, five carriers would deliver 0.6 watts per carrier. This level would produce an intermodulation product greatly exceeding the Commission's specifications for spurious emissions, which sets a spurious emission floor of -13 dBm, or 50 microwatts. This is the minimum spurious output specification that should be applied to **any booster**, whether Class A or Class B. It is, in fact, the level required by the present type-acceptance procedure used by the FCC for signal boosters. The rules are an extrapolation of those applied to transmitters. TX RX submits that the Commission should not, however, apply rules for a single carrier device, such as a transmitter, to a multi-carrier device, such as a Class B signal booster.

16. At present, type acceptance for a Class B signal booster is available at the 1 dB output compression power level, since it is tested with only one carrier present, and it will meet the spurious output power level of -13 dBm. In real life, there will be more than one carrier that can pass through the amplifier, desired or undesired. This window of acceptance can be controlled to some degree by input

filtering, but not sufficiently to eliminate all unwanted carriers.[3]

17. TX RX emphasizes that the amplification of other system frequencies in the area does not cause a negative result, as long as they are passed through with no harmful intermodulation (spurious output) generated. The obstruction which is overcome by the application of the signal booster also obstructs the reception of other frequencies.

18. Application of the same rules which control spurious output of transmitters to either class of signal booster is sufficient to guard against harmful interference. The Commission should retain its requirement that operators must cure any interference created or else cease operation.

19. TX RX opposes the Commission's proposed formulaic approach for determining the output power level of

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[3] The 800 MHz and 900 MHz trunk systems have special requirements. For example, it might be necessary to allow a passband wide enough for system trunk frequencies, which are interspersed with frequencies from a nearby system. If their input level to the booster is 10-15 dB below the desired system frequencies, their contribution to overall power is minimal and they will not adversely affect the spurious output level.

multichannel Class B signal boosters. TX RX recommends a method put forth in Appendix I, which is the Electronic Industries Association ("EIA") Proposed Standard PN 2009. Specifically, paragraph eight of Appendix I denotes a procedure for determining multi-carrier power level based on the measured third-order output intercept point of the total booster amplifier. By inserting this value, in dBm, and the number of carriers to be amplified into the formula, the maximum allowable level per carrier may be ascertained. Appendix II is a spreadsheet which provides the maximum permissible amplifier output power per carrier as a function of amplifier output third-order intercept point and number of carriers.

20. TX RX provides an output level control circuit in its Class B signal boosters which automatically applies this formula. The proper DC control voltage is derived from sampling the composite RF carrier levels at the output of the last amplifier stage. A PIN diode attenuator at the input to the amplifier chain is controlled by an OP amp that increases the attenuation if the output approaches a pre-set level. This operating position is established by observing the intermodulation level when two equal carriers are passed through the booster. The attenuator control voltage is set to take effect 1 dB below the output level, which meets the

FCC specification for spurious emissions. The effect of this circuit is demonstrated on the attached response curve in Appendix III.

21. The top display in Appendix III shows the maximum output level allowed for two carriers that meet the Commission's maximum allowable spurious emission level. The bottom display in Appendix III shows the result of injecting six carriers at the same level as the two previous carriers. One would normally expect to see six carriers all at the same level as the previous two This would be the case if the original input levels were low enough such that the intermodulation products did not exceed -13 dBm. However, two carriers were already at the maximum level allowed; hence, six carriers require a lower input level to the preamp chain, and the output level control ("OLC") circuit inserts sufficient attenuation at the preamp chain input to achieve this result.

22. TX RX believes that an OLC circuit should be required on any Class B booster that re-radiates a signal into above-ground terrain. Signal boosters that are cascaded down a radiating cable could be exempt from this requirement, since they receive their signals from an

interface or off-air booster with OLC circuits. Part 15 rules adequately address this situation.

III. CONCLUSION

23. TX RX appreciates the Commission's efforts to adapt regulatory policy to reflect the usefulness of signal boosters in contemporary telecommunications systems; TX RX believes that the Commission's Notice goes a long way toward accomplishing that worthy goal. With the exception of the three issues addressed herein -- the Part 22 VHF paging operations, the 500 milliwatt limit and the Class B output power determination -- TX RX supports adoption of the Commission's proposals.

24. Part 22 VHF paging is important to the effective operations of hospitals, nuclear plants, and other large facilities. Signal boosters are essential for distribution of Part 22 VHF paging communications within such structures.

25. The Commission has proposed an arbitrary output power limit of 500 milliwatts for single-carrier operation or 500 milliwatts divided by the number of carriers for multiple-carrier operation. If adopted, these limitations would impose severe restrictions on the availability of

signal boosters in real-world communications systems, where relatively high source levels are often required to overcome high propagation and signal distribution network losses.

26. In many cases, the Commission's proposed limitations would force users to employ more expensive, multichannel Class A signal boosters in situations where very satisfactory results could be achieved with Class B signal boosters. TX RX urges the Commission to permit the spurious emission limits to determine the allowable output levels for both Class A and Class B boosters.

27. In addition, TX RX believes that the Commission should require Class B boosters (except those cascaded in tunnels and subject to Part 15 rules) to be supplied with OLC circuitry, rather than using the proposed formulaic approach. With these three changes, the expansion of the use of signal boosters as proposed by the Commission in its Notice will help licensees to maximize their use of radio systems.

WHEREFORE, THE PREMISES CONSIDERED, TX RX Systems, Inc. respectfully submits the foregoing Comments and urges the Federal Communications Commission to act in a manner consistent with the views expressed herein.

Respectfully submitted,

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Dated: August 14, 1995

APPENDIX I

Electronic Industries Association

ENGINEERING DEPARTMENT

Committee Correspondence

AN EXCERPT FROM

EIA STANDARD PN 2009
PROPOSED MINIMUM REGULATORY REQUIREMENTS
FOR CELLULAR BOOSTERS
July 31, 1987

8) Booster Intermodulation Spurious Emissions:

All boosters utilizing a single amplifier to amplify two or more signals simultaneously shall meet the following emission limitations:

Conducted booster intermodulation products at a radiating antenna terminals are formed from the mixing of all input signals, authorized or unauthorized, with one another within the booster. These spurious emissions shall not affect the quality of the information being boosted intentionally or unintentionally. The booster peak intermodulation spurious emissions shall be attenuated below the maximum power output per authorized signal by at least $43 + 10 \log_{10}$(maximum output power per authorized signal in watts) decibels with all signals it is authorized to boost keyed simultaneously. The maximum power per authorized signal is defined to be the maximum power an unmodulated individual authorized signal is capable of producing at the output of the booster when a booster station is optimized to guarantee this minimum level of intermodulation spurious emissions.

As a general rule, if all unauthorized signals are 10 dB below the authorized signals *at the input to the booster amplifier*, compliance may be demonstrated by optimizing the booster station such that the maximum booster output power per authorized signal shall not exceed:

Maximum Output
Power per authorized
signal $= (2/3)\,[\mathrm{OIP} + 0.409 - 24.75 \log_{10}N + 1.437\,(\log_{10}N)^2]$ dBm

where: OIP = Third Order Output Intercept Point Of The Booster, Expressed In dBm, As Type Accepted For The Particular Linear Amplification Path For The Channel's Spectrum (i.e. base Tx or mobile Tx).

N = Number Of Authorized Signals For The Particular Spectrum (all signals having equal power)

Extrapolation of the third-order output intercept point shall be based upon data measured using two equal-power signals spaced 120 kHz apart and positioned in the center of the passband such that the intermodulation products fall within the booster passband. These two signals shall be applied to the booster input and their levels adjusted such that each signal at the booster output is 10 dB below the 1 dB compression point (1 dB compression point shall be measured with a single signal).

The third-order output intercept point shall be determined from the measured data by the following equation:

$$OIP\ (dBm) = Po\ (dBm) + IMR\ (dBc) / 2$$

where Po is the power level, in dBm, of one of the two signals as measured at the booster output, and IMR is the difference, in dB, between Po and the power level of the most predominant intermodulation product present at the booster output.

In addition, the third-order output intercept point shall be specified under all specified operating conditions (e.g. if the OIP is affected by the gain setting). The manufacturer shall supply either the minimum (i.e. worst case) output intercept point or a chart or formula to determine the intercept point for the specified operating condition. Such data shall be used by the station operator to demonstrate compliance as required above.

This general rule yields the maximum output power per authorized signal which shall be allowed for a unidirectional booster or a bi-directional booster employing separate linear amplification paths for each spectrum (i.e. base Tx spectrum or mobile Tx spectrum). If a cellular booster is configured in a manner other than as stated above, then a different rule not in excess of that prescribed in FCC Part 22.106, 22.906, and 22.907 shall be supplied by the manufacturer upon application for type acceptance with the understanding that the overall goal for spurious emission is to be attained with all authorized signals keyed simultaneously.

Stability:

For any booster relying upon the isolation between the booster input and output ports, the isolation between input and output circuits of the booster, including the receiving and transmitting antenna system shall be at least 15 dB greater than the maximum overall operating gain of the booster amplifier. However, a minimum isolation of no less than 9 dB can be used if it can be shown by measurements of the installed antenna system and analysis that the booster station will maintain this level over the worst case extremes of electrical, physical, and climatic conditions at the site where it will be located. (NOTE: Adapted from FCC Code of Regulations Part 74, Subpart I Instructional Television Fixed Service Paragraph 74.950 although this states an isolation minimum requirement of 20 dB.)

APPENDIX II

MAXIMUM PERMISSIBLE AMPLIFIER OUTPUT POWER PER CARRIER (dBm)
AS A FUNCTION OF AMPLIFIER OUTPUT IP3 AND NUMBER OF CARRIERS

IP3 (dBm)	MAXIMUM POWER PER CARRIER (dBm) FOR SPECIFIED CARRIERS N=1	N=2	N=4	N=6	N=8	N=16	N=32
+10.0	+6.9	+2.1	-2.6	-5.3	-7.2	-11.5	-15.7
+20.0	+13.6	+8.7	+4.0	+1.3	-0.5	-4.9	-9.1
+30.0	+20.3	+15.4	+10.7	+8.0	+6.2	+1.8	-2.4
+32.0	+21.6	+16.7	+12.0	+9.3	+7.5	+3.1	-1.1
+34.0	+22.9	+18.1	+13.4	+10.7	+8.8	+4.5	+0.3
+36.0	+24.3	+19.4	+14.7	+12.0	+10.2	+5.8	+1.6
+38.0	+25.6	+20.7	+16.0	+13.3	+11.5	+7.1	+2.9
+40.0	+26.9	+22.1	+17.4	+14.7	+12.8	+8.5	+4.3
+42.0	+28.3	+23.4	+18.7	+16.0	+14.2	+9.8	+5.6
+44.0	+29.6	+24.7	+20.0	+17.3	+15.5	+11.1	+6.9
+46.0	+30.9	+26.1	+21.4	+18.7	+16.8	+12.5	+8.3
+48.0	+32.3	+27.4	+22.7	+20.0	+18.2	+13.8	+9.6
+50.0	+33.6	+28.7	+24.0	+21.3	+19.5	+15.1	+10.9
+53.0	+35.6	+30.7	+26.0	+23.3	+21.5	+17.1	+12.9
+56.0	+37.6	+32.7	+28.0	+25.3	+23.5	+19.1	+14.9
+60.0	+40.3	+35.4	+30.7	+28.0	+26.2	+21.8	+17.6
+63.0	+42.3	+37.4	+32.7	+30.0	+28.2	+23.8	+19.6

N = Number of Carriers

IP3 = Net repeater amplifier system output third-order intercept point in dBm (amplifier IP3 minus filter and cable losses).

P(max) = (2/3)*[IP3+0.409-24.75*log(N)+1.437*(log(N)^2)]

per EIA Standard PN 2009 (July 31, 1987). Assumes equal carrier amplitudes. A carrier 15 dB below desired output makes a negligible contribution to total power output.